FINDING OF NO SIGNIFICANT IMPACT

for

Selenium Supplementation of Animal Feeds

FAP 2201

The American Feed Industry Association, Inc.

The Center for Veterinary Medicine has carefully considered the potential environmental impact of this action and has concluded that this action will not have a significant effect on the quality of the human environment and that an environmental impact statement therefore will not be prepared.

The American Feed Industry Association, Inc. [AFIA, previously the American Feed Manufacturers Association, Inc. (AFMA)] of Arlington, Virginia has filed a food additive petition (FAP 2201) with the Food and Drug Administration (FDA) that proposes that the selenium levels used in animal feeds as a nutritional supplement be increased to a uniform 0.3 mg of selenium per kilogram of animal feed. The FDA published a notice in the Federal Register (51 FR 6321, February 21, 1986) that this petition had been filed. The FDA has decided to grant this increased use of selenium. Specific limitations on the use of selenium in animal feeds are stated in the regulation approving this food additive petition.

The AFIA claims that selenium has been found to be an essential nutrient for most animals and that most animal feeds in the United States are apparently deficient in this element. The AFIA proposes that the maximum level of selenium supplementation of the animal feeds for most species of food-producing animals shall not exceed 0.3 ppm (parts per million) on a complete feed or ration basis, and shall not exceed 3 mg/head/day for cattle or 0.7 mg/head/day for sheep when selenium is given in a salt-mineral mix.

An Environmental Impact Analysis Report (EIAR, dated January 10, 1986) that examines the potential environmental impacts of approving this petition has been prepared by AFIA and is attached to this Finding of No Significant Impact (FONSI). Previous environmental documents have already evaluated the potential impacts associated with allowing selenium supplementation of the diets of several animal species grown for human food. These other publicly available environmental documents consist of: 1) an EIAR (July 26, 1972) and an Environmental Impact Statement (January 8, 1974) for selenium supplementation of the diets of chickens, turkeys, and swine; 2) an EIAR (August 26, 1976) and three Environmental Assessment Reports (November 21, 1977, June 6, 1978, and November 20, 1978) for selenium supplementation of the diets of ruminants (sheep, beef cattle, and dairy cattle); 3) an EIAR (March 13, 1981) for selenium supplementation of the diet of ducks; 4) an Environmental Assessment (EA, dated April 24, 1981) for the addition of selenium to the feed of laying hens; and 5) an EA (June 1, 1981) for an increase in the supplementation level of selenium in the diet of weanling swine.

Until now, the EA prepared for laying hens (Zeeman and Boyd, 1981) included the most comprehensive evaluation of potential environmental introductions, environmental fate and environmental effects of selenium in animal diets. Therefore, a copy of that EA was included as part of the EIAR for FAP 2201 and has also been attached to this FONSI.

The AFIA's 1986 EIAR lists the currently approved selenium supplementation levels in the feed of several food-producing animal species. The current levels of selenium feed supplementation range from 0.1 to 0.3 ppm on a complete feed basis. The proposed maximum level in the feed is a uniform 0.3 ppm (0.3 mg of selenium per kg of complete feed).

The EIAR states that the proposed new practice of selenium supplementation is estimated to result in a doubling of the current levels of selenium used for feed supplementation, or an additional 22.6 metric tons of selenium per year being introduced into the U.S. environment. This figure of 22.6 metric tons would appear to have been taken from the 1981 EA prepared for laying hens, which attempted to estimate the selenium environmental introductions resulting from the supplementation of the feeds of major food-producing animals only. The levels of selenium being introduced into the environment from the supplementation of the feeds of minor species of food-producing animals and of non-food animals has not been estimated. The figure of 22.6 metric tons of selenium per year also does not reflect subsequently approved increases in selenium supplementation of duck and weanling swine diets.

Background

The scientific literature (to 1980) describing the potential environmental effects of selenium supplementation of animal diets was referenced in the 1981 EA for laying hens (Zeeman and Boyd, 1981). Several reviews and pertinent additional scientific references on selenium in the environment have been published recently (see References). This background information has been used in this FONSI to augment the 1981 EA evaluation of the following issues:

1. Increased environmental introductions of selenium as a result of increasing the level of selenium supplementation in animal feeds.

2. Probable environmental distribution (fate) of selenium entering the environment from this use of selenium supplemented feeds.

3. Possible effects of the selenium distributed throughout the environment upon the organisms living in those environments.

Since the EA of 1981 (Zeeman and Boyd, 1981), a considerable body of new data on the environmental introduction, fate, and effects of selenium has been published. A review of this scientific data has resulted in a refinement of the levels of selenium that are likely to occur in various components of the environment and that are likely to be of concern in the aquatic environment. In addition, considerable scientific disagreement continues concerning the degree of selenium bioconcentration and bioaccumulation that is likely to occur in organisms in the environment and the significance of any such accumulation. These concerns are also briefly reviewed below. Note however, that the review of these concerns has not resulted in an appreciable change in the conclusion made in the 1981 EA for laying hens.

Environmental Introductions

The 1981 EA by Zeeman and Boyd basically reviewed the environmental consequences that could result from the use 0.1 mg selenium/kg of complete feed given to laying hens. In the 1981 EA, the increased environmental introductions of selenium were considered from both a broad (i.e., nationwide) and a local context. Both of these types of estimates are revised below to account for a) the additional scientific information currently available and, b) the additional environmental introductions expected from an increased level of selenium supplementation of animal diets.

Broad Context:

Worldwide soil erosion and weathering of rocks are reported to carry downstream each year about 10,000 metric tons of selenium to the sea (Adams and Johnson, 1981; Fishbein, 1983; Hodson et al., 1984). Eisler (1985) reports that, additionally, about 4,600 metric tons of selenium are released into the U.S. environment annually, with 33% coming from fossil fuel combustion, 59% from industrial losses, and 8% from municipal wastes. Adams and Johnson (1981) report that the total U.S. air emissions and solid waste disposal of selenium are estimated, respectively, to be about 11,000 and 31,000 metric tons/yr.

The intentional production of selenium comes primarily from the refining of copper and the Western World selenium production averaged almost 1,000 metric tons/yr from 1964 to 1973 (Fishbein, 1983) and over 1,400 metric tons/yr from 1979 to 1983 (Manser, 1984). Selenium production levels for 1984 were projected to be over 1,400 metric tons (Fishbein, 1983; Manser, 1984). This selenium is used predominantly in the electronics, plastics and glass industries. Manser (1984) says that the agricultural uses of selenium (in animal feeds, in fertilizers, etc.) account for less than 10% of the consumption of selenium produced in the Western world.

The production of selenium in the U.S. from 1979 to 1983 averaged over 250 metric tons/yr and was projected to remain at that level in 1984 (Manser, 1984). The consumption of selenium in the U.S. increased from about 400 metric tons in 1977 to over 650 metric tons in 1983 (Manser, 1984). The bulk of the difference between U.S. production and consumption of selenium is made up for by importing selenium compounds into the U.S., primarily from selenium produced in Canada and Japan.

In their 1986 EIAR, the AFIA estimates that the total environmental introductions of selenium that result from the current practice of selenium supplementation of animal diets in the entire U.S. is about 22.6 metric tons/yr. They also estimate that the new uniform level of 0.3 ppm selenium supplementation of animal diets would "on a worst case basis" result in a doubling of the expected environmental introductions in the U.S. to about 45 metric tons/yr. The proportion of total selenium consumption in the U.S. that is represented by the selenium supplementation of animal diets could therefore increase by about 3.5% (from the current 3.4% of total U.S. consumption of selenium to a projected 6.9% of total U.S. consumption of selenium).

Local Context:

In local environments, the most significant direct increases in selenium introductions are likely to be seen in agricultural soils amended with animal wastes from animals given selenium supplementation at 0.3 ppm in their diet. The absolute and relative amounts of selenium that could be introduced into the terrestrial environment were examined using the following animal and soil models.

A. Animal Models

The three most significant (i.e., largest) groups of food-producing animals in the U.S. that are given selenium supplementation are cattle, swine and poultry. Therefore, models of the use of selenium in these three species and the environmental introductions that would result from these uses should account for the major introductions due to selenium supplementation in the United States. Most of the selenium from this use should ultimately enter the terrestrial environment via the application to soil of excreta from selenium-supplemented animals. The probable range of selenium concentrations in animal excreta that could enter the terrestrial environment will be adequately covered by the use of the three estimates given below.

The EPA (1974) published a document that dealt with effluent limitations for a wide variety of animal feedlots. Data from that document were used to estimate the feed intake (and selenium input) and waste excreted (and selenium output) for beef cattle, swine and chickens raised under typical management conditions. These three species of animals reach market weight after different periods of time, however, as they will probably all be continuously supplemented with selenium, the relative concentrations of selenium in their respective wastes should be fairly constant.

1. Beef cattle: In 19-26 weeks, steers starting at about 270 kg reach an average market weight of 477 kg. Over that time period, the average steer is fed 9 kg feed/day and excretes 22 kg raw waste/day. The bulk of the raw waste excreted is made up of water drunk by the animal. Nine kg of feed

supplemented at 0.3 mg/kg results in 2.7 mg/head/day selenium intake due to supplementation. Assuming that, in the worst-case, essentially all of the selenium is excreted, the selenium concentration in wet cattle waste should be no higher than about 0.12 ppm (2.7 mg/22 kg = 0.12 mg/kg = 0.12 ppm).

2. Swine: In 23-25 weeks, feeder pigs weighing about 25 kg reach an average market weight of 100 kg. Over that time period, the average pig is fed 2.2 kg feed/day and excretes 3.5 kg of raw waste/day. That weight of feed supplemented at 0.3 mg/kg results in a daily selenium intake of 0.66 mg/head. Assuming that essentially all of the selenium is excreted, the selenium concentration in wet swine wastes should be no higher than about 0.19 ppm (0.66 mg/3.5 kg = 0.19 mg/kg = 0.19 ppm).

3. Poultry: In 6-8 weeks, chicks weighing about 5 g become marketable broilers weighing an average of 1.8 kg. Over that time period, the average bird is fed 0.064 kg feed/day and excretes 0.054 kg of raw waste/day. That weight of feed supplemented at 0.3 mg/kg results in a daily selenium intake of 0.019 mg/bird. Assuming that essentially all of the selenium is excreted, the selenium concentration in the wet poultry wastes should be no higher than about 0.36 ppm (0.019 mg/0.054 kg = 0.36 mg/kg = 0.36 ppm). Of these three models, note that the poultry excreta contains the highest concentration of selenium.

B. Soil Models

Animal manure is very often disposed of via direct incorporation into the soil as a fertilizer. The rates of manure use will vary depending upon several circumstances (e.g., soil type, manure type, rainfall, etc.). For the purpose of this assessment, the following maximum practical manure application rates/year were used (Fairbank, 1983; Fuller and Warrick, 1985).

	Manure Application Rates	
Manure Type	Tons/Acre	Metric Tons/Hectare
Cattle Wastes	15	33.7
Swine Wastes	10	22.5
Chicken Wastes	7.5	16.8

The top six inches (15.2 cm) of soil in a one acre plot of soil weighs about two million lbs (909,000 kg). Therefore, that depth of soil in a one hectare (ha) plot (ha = 2.47 acres) would weigh about 2.25 million kg. One metric ton = 1,000 kg (2,200 lbs).

The following three examples estimate: a) the total amounts of selenium that could be introduced into a part of the terrestrial environment from manure amendment, and b) the relative increase in concentrations of selenium that could result from this incorporation of manure into soils.

Example 1: Cattle wastes incorporated into soil at 33.7 metric tons/ha would result in a total of 4.04 g of selenium from supplementation being added to the top 15.2 cm of each hectare of soil (0.12 mg selenium/kg waste X 33,700 kg waste/ha = 4,044 mg selenium/ha = 4.04 g selenium/ha).

The relative concentration of selenium in the top 15.2 cm of soil amended with such cattle wastes would be increased by about 1.8 parts per billion (ppb = ug/kg; 4,044 mg selenium/2.25 million kg soil = 0.0018 mg/kg = 1.8 ug/kg = 1.8 ppb).

Example 2: Swine wastes incorporated into top soil at 22.5 metric tons/ha would result in a total of 4.28 g of selenium from supplementation being added to the top 15.2 cm of each hectare of soil (0.19 mg selenium/kg waste X 22,500 kg waste/ha = 4,275 mg selenium/ha = 4.28 g selenium/ha).

The relative concentration of selenium in top soil amended with such swine wastes would be increased by about 1.9 ppb (4,275 mg selenium/2.25 million kg soil = 0.0019 mg/kg = 1.9 ug/kg = 1.9 ppb).

Example 3: Chicken wastes incorporated into top soil at 16.8 metric tons/ha would result in a total of 6.05 g of selenium from supplementation being added to the top 15.2 cm of each hectare of soil (0.36 mg selenium/kg waste X 16,800 kg waste/ha = 6,050 mg selenium/ha = 6.05 g selenium/ha).

The relative concentration of selenium in top soil amended with such chicken wastes would be increased by about 2.7 ppb (6,050 mg selenium/2.25 million kg soil = 0.0027 mg/kg = 2.7 ug/kg = 2.7 ppb).

In the following section on environmental fate, these increases in soil selenium level will be compared to the background levels of selenium already present in soils. The overall movement (flux) of selenium into and out of such an amended soil will also be estimated. The flux of selenium into the other environments represents the potential levels of selenium that might be transferred from the terrestrial environment into the aquatic environment and into the atmospheric environment. Finally, in the environmental effects section, these levels of selenium will be compared to those known or expected to result in adverse effects upon organisms present in the environment.

Environmental Fate

The form and concentration of selenium in soils, water, the atmosphere, and the biota can vary greatly (Bennett, 1983; Eisler, 1985; EPA, 1986; Fishbein, 1983; Hodson et al., 1984; Medinsky et al., 1985; Robberecht and Von Grieken, 1982; Shamberger, 1983; Sharma and Singh, 1983; Wilbur, 1980 & 1983). The actual rates of selenium transfer between each of these diverse environmental components are very difficult to establish, as they vary by locality. The simplest manner to deal with this very complex issue is to attempt to model the selenium background and the diverse selenium inputs and outputs from an example environmental compartment that could be most directly impacted by the supplementation of animal feeds with selenium (i.e., one hectare of soil amended with animal wastes).

There are indications that selenium taken up by organisms in the aquatic environment could, in unusual circumstances, have significant environmental effects (Eisler, 1985; Finley, 1985; Lemly, 1985 a & b; Ohlendorf et al., 1986; NCDNR&CD, 1986). Therefore, an extreme example of aquatic introductions of selenium from soils amended with high levels of animal wastes will also be considered.

Soil Example:

The maximum increase in soil selenium levels would occur from the amendment of top soil with poultry wastes at a rate of 16.8 metric tons/ha/yr. This results in an increase of topsoil selenium concentration of about 2.7 ug selenium/kg of soil/yr, or a total input of selenium from poultry waste disposal of about 6.05 g/ha/yr. These values need to be compared with the background levels of selenium already present in soil. Bennett (1983) states that 0.4 mg selenium/kg soil is a representative concentration of selenium in agricultural soils, as it is the geometric mean of the normal range of selenium in cultivated surface soils . That level of selenium in soils represents a total of almost 900 g of selenium in the top 15.2 cm of soil in a hectare of land (0.4 mg selenium/kg soil X 2.25 million kg/ha = 898,092 mg/ha = 898 g/ha). Therefore, the amount of selenium in a poultry waste amendment represents an annual increase of about 0.67% of the selenium already present in the top 15.2 cm (6") of an average agricultural soil in the U.S.

Several scientists make the argument that the selenium levels in soils are often low and therefore selenium supplementation of animal feeds (either directly in the feed, or as a spray on food and forage plants, or included as an additional component of fertilizers used on the soils for such food plants) has become more necessary recently because of declining levels of selenium in plants grown in many places in the world (Frost, 1984; Gissel-Nielsen, 1984; Korkman, 1984; Sharma and Singh, 1983; Wilbur, 1980 & 1983). There is a concern that the selenium levels in many soils are being depleted and that the selenium cycle is "running down" due to increases in plant production, increased soil leaching of selenium because of acid rain, and decreased availability of selenium to plants due to increased fertilizer uses (Frost, 1984; Gissel-Nielsen, 1984; Sharma and Singh, 1983).

In fact, soils in Scandinavia and New Zealand often require the direct addition of about 10 g of selenium/ha in their fertilizer applications. This use in Finland and New Zealand alone will result in the use of from about 10 to 25 metric tons of selenium/yr (Gissel-Nielsen, 1984; Korkman, 1984).

Therefore the relatively small increase in total selenium in agricultural soils due to animal manure amendment should have a minimal impact upon the levels of selenium already available for transport into other environmental compartments. It is possible that this addition to soils may even be considered to be beneficial in those soils which are (or could become) deficient in levels of selenium necessary for adequate plant selenium uptake.

The selenium level in any specific environmental compartment usually represents the balance reached between the level that is already there and the dynamic additions and deletions that are occurring over time. Below is a list of reasonable estimates of the background selenium level found in an average agricultural soil and the selenium flux (inputs and outputs) that could result due to: a) soil amendment with manure, b) rainfall, c) direct deposition onto soil, d) volatilization from soil, e) runoff from rainfall, and f) harvesting of crops grown in this soil.

Selenium Flux in an Example Waste-Amended Soil

1. Background: 900 g selenium/ha (Bennett, 1983).

2. Inputs: Total = 9.4 g selenium/ha/yr.
   a. Amendment = 6.0 g selenium/ha/yr (poultry model).
   b. Rainfall = 1.3 g selenium/ha/yr; 25" rain/yr with 0.2 ppb selenium (Hodson et al., 1984; Robberecht & Von Grieken, 1982).
   c. Deposited = 2.1 g selenium/ha/yr; air (dry) deposition rate of 1.3 ng/m^3 (Bennett, 1983).

3. Outputs: Total = 2.1 g selenium/ha/yr.
   a. Volatilize = 0.8 g selenium/ha/yr; average of spring rate and fall rate (Zieve & Peterson, 1981).
   b. Runoff = 0.3 g selenium/ha/yr; 25% of selenium in rainfall on soil runs off (Hodson et al., 1984.)
   c. Harvest = 1.0 g selenium/ha/yr; average of corn at 6,300 kg/ha (100 bushels/acre, 56 lbs/bu) and wheat at 4,000 kg/ha (50 bushels/acre, 70 lbs/bu). Mean selenium concentration in terrestrial plants of 0.2 mg/kg (Wilbur, 1980 & 1983).

Therefore, for this example, the overall selenium inputs are larger than the selenium outputs by about 7.3 g/ha/yr. This would mean that, on average, the selenium levels in this soil would tend to increase by about 0.8% per year, a level that does not seem to be very significant.

The selenium outputs from this soil to the atmosphere and to the aquatic environment also do not appear to be very significant.

Aquatic Example:

Pesticides which are incorporated into soil may show seasonal losses to runoff of about 0.5%, however, these losses "can increase three-fold if runoff occurs within 2 weeks after application." (Willis and McDowell, 1982).

A worst-case example of possible selenium introductions into aquatic systems from soils freshly amended with manure will illustrate the maximum additional levels of selenium attributable to the waste amendment that can be expected to enter the aquatic environment. Assume that a large runoff event (4" rain with 2" of runoff) occurs shortly after poultry excreta has been incorporated into the soil of a 10 ha watershed at the maximum practical application rate. Assume further that a range of from 1 to 10% of the total selenium in this excreta is carried in the runoff from this 10 ha watershed into a one ha farm pond that is two meters (6.5') deep. The maximum additional selenium concentration in the runoff or in the farm pond would be about 1.2 ppb or 0.24 ppb (ug selenium/kg water), respectively. This is the concentration that would be added to selenium naturally present in the runoff and ponds at that locality.

Calculation

Given:

Maximum total selenium from excreta = 6.05 g/ha = 60.5 g/10 ha watershed.
Two inches rain runoff = 507,800 kg/ha = 5.08 X 10^6 kg/10 ha watershed.
One ha pond 2 m deep = 20 million liters water = 20 x 10^6 kg/ha pond.
Total water in pond (including 2" runoff) = 25.08 X 10^6 kg

Case 1: Selenium concentration range in runoff.
a) 60.5 g selenium/10 ha X 1% = 0.605 g = 605 mg selenium
605 mg selenium/5.08 X 10^6 kg runoff = 0.00012 mg/kg = 0.12 ppb

b) 60.5 g selenium/10 ha X 10% = 6.05 g = 6,050 mg selenium
6,050 mg selenium/5.08 X 10^6 kg runoff = 0.0012 mg/kg = 1.2 ppb

Case 2: Selenium concentration range in pond (after runoff dilution).
a) 1% of selenium from 10 ha watershed = 605 mg selenium
605 mg selenium/25.08 X 10^6 kg water = 0.000024 mg/kg = 0.02 ppb

b) 10% of selenium from 10 ha watershed = 6,0500 mg selenium
6,050 mg selenium/25.08 X 10^6 kg water = 0.00024 mg/kg = 0.24 ppb

These two cases assumed that the rainfall and the pond water were initially selenium free. In fact, natural environmental waters demonstrate a wide range of levels of selenium.

In unusual circumstances, selenium concentrations of from 10 ppb to 300 ppb in surface waters have been reported (Eisler, 1985; Lemly 1985a & b; Ohlendorf et al., 1986; NCDNR&CD, 1986). However, the selenium concentrations in most lakes and rivers are 1 ppb or less (Adams and Johnson, 1981; Shamberger, 1983). Adams and Johnson (1981) report that samples from the Illinois, Missouri, and the Mississippi Rivers ranged from 0.3 to 1.0 ppb and averaged 0.6 ppb selenium. Wilbur (1980 & 1983) states that major rivers average about 0.2 ppb selenium, that the mean value for major U.S. drainage basins is also 0.2 ppb, and that the selenium concentration in natural waters averages about 0.25 ppb. From a survey of selenium in freshwater, Bennett (1983) reports that the range and median concentrations of selenium were 0.02-1 ppb and 0.2 ppb, respectively. Hodson and Hilton (1983) said that the typical selenium concentrations in surface waters was <0.1-0.4 ppb.

The above worst-case calculations of introductions of selenium from a 10 ha watershed into a pond indicate that the levels of selenium that might be added to natural waters are around the average levels that are already likely to be found in such waters. These levels of selenium are nowhere near those demonstrated to be an acute or chronic toxicity problem to organisms living in the aquatic environment (see below).

Environmental Effects

Terrestrial Environment:

There would appear to be little or no environmental concern about the relatively small additional introductions of selenium to the terrestrial environment that would occur as a result of selenium supplementation of animal diets. The levels anticipated would most probably not significantly affect terrestrial organisms (Eisler, 1985; Sharma and Singh, 1983; Wilbur, 1980 & 1983). The forms of selenium found in animal raw wastes have been reported to be essentially unavailable to plants (Frost, 1984; NRC, 1983; van Dorst and Peterson, 1984). In part, this may be due to the strong binding of some forms of selenium to soils (Gissel-Nielsen, 1984; Sharma and Singh, 1983; van Dorst and Peterson, 1984; Wilbur, 1980 & 1983).

Aquatic Environment:

Research has been reported recently on: a) selenium deficiency in aquatic animals (Eisler, 1985; Hodson and Hilton, 1983; Keating and Dagbusan, 1984; Winner, 1984), b) the dynamics of selenium uptake and loss by aquatic organisms (Bennett et al., 1986; Eisler, 1985; Hilton et al., 1982; Hodson et al., 1984; Kleinow and Brooks, 1986 a & b; Lemly, 1982), and c) the acute and chronic toxicity of selenium to a variety of aquatic organisms (Adams and Johnson, 1981; Dunbar et al., 1983; EPA, 1986; Eisler, 1985; Halter et al., 1980; Hodson et al., 1984; Klaverkamp et al., 1983; Lemly, 1985 a & b; NCDNR&CD, 1986; Reading and Buikema, 1983; Sato et al., 1980;

Sorensen et al., 1984; Ward et al., 1981). Most of these research articles indicate that the levels of selenium that could be introduced into the aquatic environment by the use of selenium supplementation of animal foods are very unlikely to result in any effects upon aquatic organisms.

The major area of concern about the environmental effects of selenium appears to focus on possible adverse impacts upon fish and wildlife that live in or near aquatic environments that are contaminated with high levels of selenium (Baumann and May, 1984; Eisler, 1985; Lemly, 1985 a & b; Ohlendorf et al., 1986; Sorensen et al., 1982 & 1984).

The items that are the most significant in this issue center upon: a) the extent of selenium bioconcentration and bioaccumulation that occurs in the aquatic environment, and b) the significance of these selenium residues to animals eating aquatic species from this environment. There continues to be considerable scientific controversy about the issue of selenium bioconcentration and bioaccumulation.

1. "There is no bioaccumulation of selenium in the food chain" (Gissel-Nielsen, 1984).
2. "There seems to be no evidence for biomagnification of selenium by aquatic organisms" (Wilbur, 1980).
3. "The biological half-life for Se in mammals is only a few weeks, which excludes the risk of bioaccumulation" (Sharma and Singh, 1983).
4. "The concentration factor of selenium by carp...was not large" (Sato et al., 1980).
5. "The accumulation of selenium by aquatic organisms is highly variable" (Eisler, 1985).
6. "The uptake of selenium by invertebrates and fish through the food chain is a cause for concern" (Brooks, 1984).
7. "Selenium can accumulate and be biologically magnified to toxic levels in a reservoir even though waterborne concentrations are in the low microgram per liter range" (Lemly, 1985a).
8. "Selenium is highly bioconcentrated by aquatic organisms and is biomagnified in aquatic food chains" (Lemly, 1985b).

The dichotomy evident in this issue is probably somewhat related to the focus of each of these researchers. In a broad context (i.e., nationwide), a good case can be made that: a) the selenium levels in many U.S. feeds are inadequate for good animal nutrition (Frost, 1984; Morris et al., 1984; Wilbur, 1980 & 1983), and b) the average selenium levels in fish in the U.S. from 1972 to 1980 did not increase (increases would be expected from the potential for selenium bioaccumulation by fish) and may even have decreased (May and McKinney, 1981; Baumann and May, 1984).

In a local context, it is evident that there are some parts of the U.S. that have experienced and could continue to experience selenium excesses. Baumann and May (1984) found in a nationwide survey of fish in the U.S. that the selenium levels in freshwater fish had not increased from 1972 to 1980. However, the survey did find fish from some locations having unusually high selenium concentrations (the lakes and reservoirs draining areas of high selenium rock and soil or that were subject to large selenium influx from coal ash pond effluents).

The use of selenium as a supplement for animal feeds that are deficient in that element would be unlikely to result in any significant effects upon organisms in the environment. However, accidental misuses of selenium in animal feeds have occasionally resulted in toxicity to animals given this diet (Casteel et al., 1985; Harrison et al., 1983; Wilson et al., 1983). The individuals making decisions about selenium supplementation need to be aware not only of the possible dangers to the animals supplemented, but also the possible danger to any aquatic environments that may already be experiencing excess levels of selenium.

Conclusion

Selenium is a unique element. In small quantities, selenium is essential to life. In larger quantities, selenium causes toxic effects. Selenium can be in many chemical forms in the environment, some of which are bioavailable and accumulated in biota. However, many chemical forms of selenium are unavailable as a selenium source to biota. Selenium chemical forms cycle from bioavailable to unavailable forms and back as part of a worldwide biogeochemical cycle. Soil and rainfall acidity, soil oxygen concentration, microbial activity, soil cation exchange capacity and organic matter content, underlying geochemical composition and the quantity of rainfall all play important roles in determining whether selenium accumulates or is lost from soils. Man's activities, particularly through agriculture and the generation of acid rain, affect the equilibrium levels of selenium in soils. Intensive cropping, irrigation, and acid rain all tend to remove selenium from soil in the form of plant biomass and in runoff to surface waters. As a result, many animal feeds (and many human foods) produced in the United States are deficient in selenium. Other countries, for example Sweden and New Zealand, have similar deficiency problems which are being corrected by use of inorganic selenium in fertilizers.

Losses of selenium from soils to surface waters through runoff can also result in local excesses of selenium that, when water and sediment chemistry dictates, are bioavailable and accumulate in fish, aquatic plants, and waterfowl. The best known example of this problem is the Kesterson Reservoir in California. It is also probable that there are soils deficient in selenium within the Kesterson watershed.

The action being proposed in the AFIA food additive petition is to provide needed supplemental selenium, in a bioavailable form, to the feed of domestic animals. It is the Center for Veterinary Medicine's responsibility under the National Environmental Policy Act to determine whether approval of the food additive petition can be expected to cause significant environmental impacts.

This action is needed in large part because intensive agricultural practices deplete bioavailable selenium from soils at rates faster than it is deposited and recycled, resulting in plant materials that are deficient in selenium. When wastes from selenium-supplemented animals are amended into agricultural soils, man is, in effect, supplementing soils with selenium that may ultimately reduce the existing selenium deficiency. Selenium in animal wastes, however, is not initially in a bioavailable form. Local microbial activity and soil and rainwater chemistry determine the extent that selenium will be made bioavailable, sorbed to soil particles, or lost in runoff.

Undoubtedly, there are agricultural soils where additional selenium inputs are not needed. In these locations, it is important to monitor selenium content of soils and runoff to prevent local excesses. At the same time, any selenium contribution to these selenium sufficient soils from amendment of animal wastes would be proportionally very much smaller than the average situation addressed in the soil model above, and many of these locations could be safely amended with these wastes for years. Soil conservation and water runoff management programs also serve to limit the quantities of selenium lost from soils to the aquatic environment. Finally, it is not expected that animal feeds already sufficient in selenium will be routinely supplemented with additional selenium. Feed supplementation with selenium costs money and care must be taken by feed mixers to avoid uneven distribution of the supplement in the feed. Therefore, it is expected that selenium supplementation of feeds will be more limited in selenium sufficient areas than in deficient areas.

Selenium deficiency of soils and crops is a common and growing problem for much of the United States. Localized problems from selenium excess is a visible, but uncommon, occurrence. Management of selenium in the environment is increasingly important, due to the interference of man's activities in the biogeochemical cycling of selenium. This is a formidable challenge for landowners, soil conservationists and fish and wildlife managers.

AFIA's food additive petition attempts to address the selenium deficiency in animal feed problem. The action will indirectly help the selenium deficiency in soils and crops problems experienced in most of the United States. The increased supplementation levels of selenium in feeds that would be permitted under the AFIA petition is not expected to be a significant contributor to selenium excess problems experienced in certain localities. Due to the many biological, geological and chemical factors affecting selenium mobility in the environment, solutions to local selenium excess problems will probably have to be individually designed for each situation. Restrictions in the use of selenium-supplemented animal feed in particular locations may be a feature of individual local selenium management approaches. However, restrictions for localities as part of this food additive petition, in the absence of a local management plan, would be unlikely to be effective, perhaps be unnecessary, and is, furthermore, without legal precedent under the Federal Food, Drug and Cosmetic Act.

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